Simulation-based medical education

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Outline

- What is simulation?
- Simulation in other high-risk industries
- Simulation in healthcare
- Benefits of simulation
- Barriers to adoption of medical simulation
- **The main methods with emphasis on more advanced techniques:**
  - Simple models or manikins
  - Animal models
  - Human cadavers
  - Simulated/standardized patients (SPs)
  - Screen-based simulators
  - Realistic high-tech procedural simulators (task trainers)
  - Virtual reality
  - Realistic high-tech interactive patient simulators

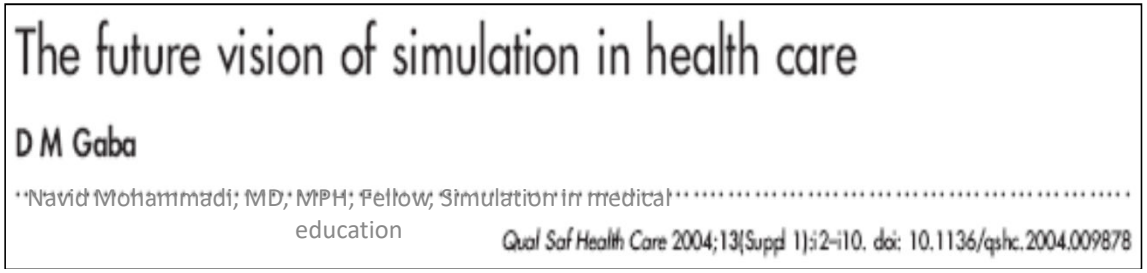
What is simulation?

- Simulation is defined as:
  - “the representation of the operation or features of one process or system through the use of another” (American Heritage Dictionary, 1992)
  - or, “the artificial replication of sufficient components of a real world situation to achieve certain goals” (Gaba, 1997).
- While simulations have been used for millennia to plan, reduce risk, and increase control (hunting rituals, wedding rehearsals, and mock battles), the term has taken on new connotations in the past 50 years.

What is simulation?

- Simulation is a technique – not a technology
- Use in Medical Education is to:

"replace or amplify real experiences with guided experiences that evoke or replicate aspects of the real world."


The future vision of simulation in health care

D M Gaba

Navid Mohammadi; MD; MPH; Fellow; Simulation in medical education

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Simulation in other high-risk industries

- Simulation in risky work:
  - Power generation (Wachtel, 1985)
  - The military (Ressler et al., 1999)
  - Transportation,
  - High-stake legal proceedings (jury selection and mock trials),
  - Professional sports training,
  - Business executives training (Keys &Wolfe, 1990),
  - Homicide investigation training,
  - Costly construction projects are other areas increasingly turning to simulation.

Simulation in other high-risk industries

- Aviation offers the most familiar example (Garrison, 1985; Rolfe & Staples, 1986).
- The concept of learning using a variety of simulation modalities became institutionalized as an integral part of a mature safety culture in aviation (Sagan, 1993).
- Currently, commercial aviators are tested in `stick and rudder' skills every 6 months for certification, and once a year for more complex, full environment performance in a high-fidelity team simulator.

Simulation in healthcare

- Interest in simulation-based medical training has increased for reasons similar to those that led to the advance of simulation in other fields:
  - risk and cost reduction,
  - improved possibilities for demonstration and assessment of a wider range of skills,
  - the availability of new technologies that enable more sophisticated simulation

Why Simulation in health care?

- 1999 Institute of Medicine report –
  - 'to err is human'
  - Highlighted the cognitive and technical errors in medical education

- Patient safety became an important agenda item
  - Licensing and governing bodies challenged to improve physician confidence and patient safety

Ethical Themes of Simulation

1. Best standards of care and training
2. Error management and patient safety
3. Patient autonomy
4. Social justice – resource allocation

"patients are to be protected whenever possible and they are not commodities to be used as conveniences of training."

Simulation-Based Medical Education:
An Ethical Imperative

ACADEMIC MEDICINE, VOL. 78, NO. 8 / AUGUST 2003

Amitai Ziv, MD, Paul Root Wolpe, PhD, Stephen D. Small, MD, and Shimon Glick, MD

Ethical Themes of Simulation

1. Best standards:

- Best standard for patient care:
  - First do no harm to patients
    - Using patients as learning instruments is only justified when all approaches to minimize risks have been taken
  - Simulation allows trainees' first encounters with real patients to be at higher technical and clinical proficiencies

Ethical Themes of Simulation

1. Best standards:

- Best standard for education
  - Responsibility of educators to provide clinicians with best training

- Best standard for evaluation
  - Traditional evaluation focused on cognitive domain
  - With simulation can assess attitudinal and psychomotor as well

Ethical Themes of Simulation

2. Error management:

- Even with supervision it is inevitable that trainees cause preventable injuries
- In clinical setting, errors must be stopped promptly
- In simulation, errors may be allowed to progress
- Errors can occur at any level in medical education:
  - SBME has uses in UME, PGME, CME

Ethical Themes of Simulation

3. Patient autonomy:

- Patients have the right to direct their own care

- Historical reports of procedures or physical exam skills being practiced on:
  - Deceased
  - Drugged
  - Anesthetized

Ethical Themes of Simulation

4. Social justice:

- Basic principle of distributive justice states:
  - Citizens equally share the risks of medical innovation, research and practice training

- Most teaching institutions are urban and provide disproportionate care to the poor and under privileged

- SBME may help equilibrate this imbalance

Simulation Based Medical Education

- Simulation is a complimentary teaching method in the medical profession:

- *"any educational activity that uses simulative aids to enhance medical educational message"*

- *"not to replace traditional methods, but to add to"*

Benefits of simulation

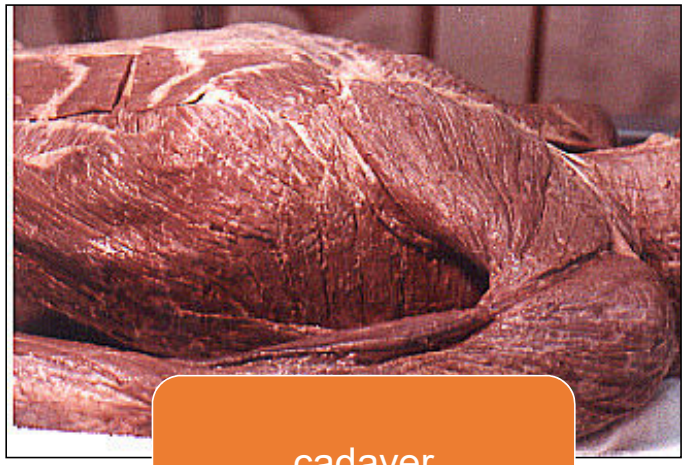
- Moral imperative
- Learner-centered education and training
- Teacher-enabled environment
- Improving performance assessment
- Approach to error management
- Improving incident reporting and safety culture
- Economic consequences
- New research horizons

Barriers to adoption of medical simulation

- Rapid, major change creates resistance
- Visible costs are relatively high, while significant cost benefits may be indirect, soft, and long term
- Lack of trainers experienced in using simulation tools and methods
- Need for more validated, reliable curricula that can be easily disseminated and operationalized

The main methods with emphasis on more advanced techniques

Mannikins



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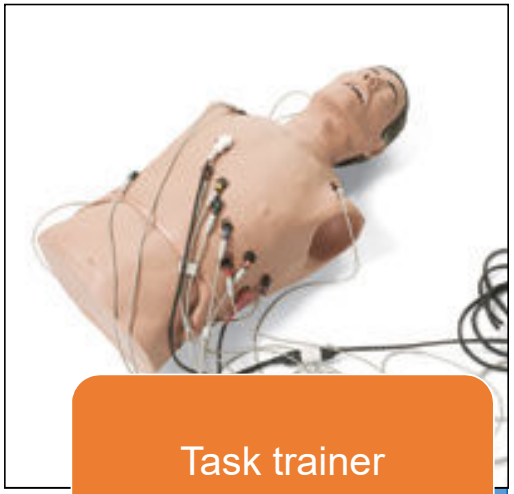

Task trainer

Virtual Reality

Simple models or manikins

- Low-tech, relatively low-cost simulators
- Used to teach basic cognitive knowledge or hands-on psychomotor skills
  - Anatomic models:
    - used to support learning about cardiac function
    - performance of spinal anesthesia
    - prostate and breast examination
  - Devices have been developed to allow:
    - practice of First Aid for various injuries/wounds,
    - insertion of intravenous catheters.
  - Simple manikins are used to:
    - train and assess basic life support maneuvers such as mask ventilation, intubation or chest compression

Animal models

- Traditionally for physiology and pharmacology education
- For training in interventional procedures, such as ATLS and laparoscopic cholecystectomy
- Growing ethical concerns in the face of the availability of better options such as improved simulation techniques
- Factors supporting this trend:
  - direct and indirect costs,
  - convenience,
  - access to exact human models as opposed to animal approximations

Human cadavers

- In medical school anatomy classes for hands-on dissection
- In surgical courses aimed at teaching practitioners new procedures
- As supplements to training in complex injection techniques for pain therapy or nerve blocks
- Considerations:
  - Expense
  - inconvenience
  - limited availability
  - use of formalin-fixed tissues

Simulated/standardized patients (SPs)

- SPs serve mostly for the training and assessment of history taking, physical examination and communication skills

- Since the introduction of the SP methodology (Barrows, 1968; Harden et al., 1975), SPs have become the single most studied simulation-based educational tool in medicine (Barrows, 1993).

- Growing recognition of the unique features and advantages of SPs has resulted in their being integrated into medical school curricula, followed by incorporation into major high-stakes licensure exams (Reznick et al., 1996; Sutnick et al., 1993).

Screen-based simulators

- Computer-based clinical case simulations were first developed in the 1960s but not until the advent of the personal computer in the 1980s did this approach to clinical education begin to proliferate.

- Since then, these tools have become increasingly prevalent in medical education to train and assess clinical knowledge and decision making as a result of their dropping acquisition cost and low maintenance.

- Screen-based simulation is available today in almost any clinical or basic science domain in medicine.

- As self-tutorials with built-in feedback features, screen-based simulators offer a comprehensive learning experience that is less dependent on the involvement of external educators.

Realistic high-tech procedural simulators (task trainers)

- highly sophisticated computer-driven realistic simulator devices has extended the envelope and complexity of tasks and procedures that can be modeled for education, training and research

- invest static models with rich audiovisual and touch/feel interactive cues, and build on powerful software for teaching, learning, and assessment.

- Harvey Cardiology Patient Simulator presents ausculatory and pulse findings of 27 cardiovascular conditions and supports a comprehensive curriculum

- ultrasound simulator that appears and operates like an actual ultrasound system, with a fully functional control panel, mock transducers and a realistic patient-manikin

Virtual reality

- a system that enables one or more users to move and react in a computer-simulated environment (Encartat Online Encyclopedia, 2000).

- Technically, true VR refers to totally synthetic environments, where cues for all senses are computer generated

- The trend in VR is for maturing technologies to be
  - first combined in hybrid approaches with simulation methods (role play with live people, use of actual tools),
  - moving to completely digitally represented worlds which real people can enter

Realistic high-tech interactive patient simulators

- Computerized, realistic patient simulators (RPSs) were first used in 1966 for anesthesia training (Denson & Abrahamson, 1969).
- The physical characteristics of `Sim-One' were surprisingly lifelike
- Computers were used to record drug levels, generate and display blood pressures and heart sounds, and control motion actuators
- `Sim-One' was an isolated phenomenon, ahead of its time; nearly two decades elapsed before advances in computer technology, bioengineering, learning and behavioral sciences led to the development of RPSs as we know them today (Gaba & DeAnda, 1988; Gravenstein, 1988).

Realistic high-tech interactive patient simulators

- RPSs are advanced in the number and detail of the features they possess and the large range of programs and trainee types they support

- The common features include a full-length manikin, a computer workstation, and interface devices that actuate manikin signs and drive actual monitors

- RPSs have eyes responsive to light, pain and selected cranial nerve palsies, an anatomically correct and dynamic airway, patient voice, arm movement, heart and breath sounds, and excretion of carbon dioxide

Realistic high-tech interactive patient simulators

- Chest-tube insertion,
- Monitoring of neuromuscular transmission using standard nerve stimulator devices
- Provision of dynamic physical cues mimicking extremity compartment syndrome are supported features.
- Physiologic computer models of
  - ventilation, gas exchange, and cardiopulmonary function
  - interact with pharmacological models
  - simulate actions of dozens of agents administered by various routes,
  - from anesthetic gases to a variety of vasopressors, narcotics, paralytics, hypnotics and fluids.

Realistic high-tech interactive patient simulators

- The physiological and pharmacological models can be automated using scripts or controlled manually through a screen-based interface.
- RPSs may be controlled at a short distance via direct or wireless means, as well as `at the bedside' by a hand-held device connected to the main workstation
- Ventilators, defibrillators, rapid transfusion devices, anesthesia machines and other devices easily interface with the RPS
- Over 150 RPSs exist worldwide following their inception in 1994

What is fidelity?

"is the extent to which the appearance and behavior of the simulation match the appearance and behavior of the simulated system"

Low- to high-fidelity simulation – a continuum of medical education?

N J Maran & R J Glavin* *Medical Education 2003;37(Suppl. 1):22–28*

"precision of reproduction, the extent to which an electronic device, for example, a stereo system or television, accurately reproduces sound or images"

Simulation: Not Just a Manikin

Michael A. Seropian, MD, FRCPC; Kimberly Brown, MSN, RN, FNP, CEN; Jesika Samuelson Gavilanes, BA; and Bonnie Driggers, MS, MPA, RN

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A. Ziv's definition of High Fidelity

1. Screen based simulator
   - May or may not interact
2. Procedural simulators (task trainers)
   - Static models with tactile cues
3. Realistic Patient Simulators
4. Virtual reality
   - Evolving technology
   - Combine virtual world with simulation +/- standardized patients to form microsystems

A. Ziv's definition of Low Fidelity

1. Simple 3-D models
2. Animal models
3. Human cadavers
   - Realistic but lack physiologic response
4. Basic Plastic Manikin
   - Simple skills trainers
   - Physical exam teachers
   - Clinical skills teachers
5. Simulated or standardized patients
   - Best for clinical skills teaching

Low Fidelity

- If simulation is a manifestation of reality
- And some models have “low fidelity”
  - Or poorly mimic reality

Can they make any difference?

i.e. Do they change behavior?